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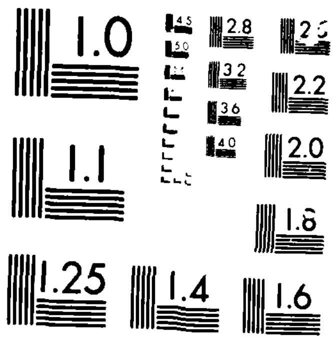

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THESIS

AN EXAMINATION OF TECHNOLOGY TRANSFER AS A TOOL FOR MANAGEMENT

by

Don Berton McCorkendale

March 1986

Thesis Advisor: J. W. Creighton

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An Examination of Technology Transfer as a Tool for Management

by

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ABSTRACT

An examination of the technology transfer process as it relates to contemporary management practice. The objective is to acquaint the reader with the concept of technology transfer and the mechanism of information flow within business organizations. Includes an in-depth analysis of the predictive model of technology transfer with an emphasis on the interrelationship between management and the factors effecting information flow.

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I. INTRODUCTION

The Naval Facilities Engineering Command (NAVFAC) has long been pursuing an effort toward making the greatest possible use of research, conducted at it's Civil Engineering Laboratory, in NAVFAC field activities around the world. In conjunction with this effort NAVFAC ,in 1967, secured the services of faculty at the Naval Postgraduate School to support the endeavor in whatever way possible. In subsequent years there has been an ongoing and coordinated research effort between the Naval Facilities Engineering Command Headquarters in Washington, DC, the Civil Engineering Laboratory at Port Hueneme, California, the Naval Postgraduate School, Monterey, California, The Office of Information of the Naval Material Command, and the California State University, Sacramento, California to identify and analyze the various mechanism by which R&D results flow into use at field activities, and more importantly, how this transfer process can be accelerated. [Ref. 1:p. v]

Since 1967 many research projects have been conducted concerning virtually every aspect of the technology transfer process. Current literature is rich with hundreds of theses, articles and papers on the topic. Despite the solid foundation currently available there is still a perceived

need within the Naval Facilities Engineering Command and elsewhere to produce an instructional document which would pull together the various research findings that treat the interactions involved in the information flow process into one source. Pursuant to this goal the objective of this paper will be to familiarize managers with the concept of technology transfer and acquaint them with the mechanism of technology transfer and its role in organization, personnel, and research management.

II. THE NATURE OF THE PROBLEM

In recent years there has been said to have been a information or technology explosion. Indeed, It seems that technology has always been society's answer to the need for increased productivity. From the lever to the wheel, the water wheel to the internal combustion engine, the cotton gin to the automobile assembly line, advances in technology have been the cornerstones of success that have fulfilled the ever increasing demands of society. The National Center for Productivity and Quality of Working life has stated that:

> Much of the historical growth of productivity in this country is the direct result of technological change. Technological advances are critical to continued productivity growth because they lead to increasingly effective use of labor, capital, and natural resources.

Edward F. Denison of the Brookings Institute has termed technological change, "the biggest single source of growth" over the past three decades [Ref. 2:p. 2]. The U.S. Department of Commerce has stated (Commerce report PB-263-806,p.178) that, "It has been estimated that technological innovation was responsible for forty five percent of the Nation's economic growth between 1929 and 1969." The Department has further stated that:

> A comparison of technology-intensive manufacturing industries with other industries in the period 1957 to

> 1973 shows that technology-intensive industries grew forty five percent faster and that employment in the technology-intensive industries grew eighty eight percent faster . . . .

These generalities concerning the role of technology in productivity growth are difficult to measure because their measurement involves so many intangibles. Nevertheless, attainment of precision in evaluating the contribution of technology to changes in productivity is becoming an important goal of research economists. One reason for the emphasis is related to the concern over the recent decline in U.S. productivity and the possible role of technological developments in that decline. The United States has long been recognized as the world leader in development of new technology, but in recent years concern has been expressed that America's spirit of innovation may be waning. Productivity, as measured in output per man hour, actually declined by 2.7 percent between 1973 and 1974, the first drop in 15 years. In a national policy statement, issued several years ago, the National Center for Productivity warned that:

> . . . technological leadership of the United States . . . may be threatened by both a recent lessening of our basic research activities and by an increasing inability to make effective use of scientific knowledge and technical know-how we already have. [Ref. 2:p. 3]

Of course, not everybody shares this dismaying conclusion regarding the apparent productivity decline, and many explanations have been offered which tend to reflect that

America's productivity or capacity for innovation are not in crisis.

Wheather or not there is truly a productivity problem, the fact that the issue has been raised illustrates the point that innovation or the active transfer of technology is not a process that can be assumed or be taken for granted. Clearly the movement of technology from source to user is an important factor in the potential success of any enterprise or organization whether it be in the private or public sector. The quest for new ideas and new ways of doing things is a process which needs to be understood and managed just as equipment, money, and other resources are managed.

The meaning of the phrase "technology transfer" is ambiguous. In the current literature, many definitions are provided. The Directory of Federal Technology Transfer defines the term as follow: ". . . the process by which existing research knowledge is transferred operationally into useful processes, products, or potential public or private needs . . . ." The general accounting office offers this definition: ". . . the secondary application of technology developed for a particular mission or purpose to fill different needs in another environment . . . ." And the National Academy of Engineering provides this definition: "The process of collection, documentation, and successful dissemination of scientific and technical

information to receiver through a number of mechanisms . . . ." [Ref. 3: p. 104]

These definitions are very similar, yet useful distinctions can be drawn between the contemporary interpretations of meaning. One major connotation of the phrase, as seen in the National Academy of Engineering definition, is the transfer from one location to another of technical knowledge, processes or instruments that then will be used for essentially the same purpose. This transfer could take place between companies, states or nations. The transfer of semiconductor manufacturing capability to Japan or other countries is one example [Ref. 4:p. 57]. Technology transfer in this context is an extensive subject of international policy and legislation, but is beyond the scope of this paper and will not be discussed further.

The other technology transfer definitions provided indicate a second major connotation for the term. The adaptation of technical knowledge or information from its original purpose or intended use to another purpose or application. Examples of this type of transfer include such things as grooving of highways to prevent hydroplaining, originally developed for commercial Airline runways, and the covering of stadiums, malls and other structures with a teflon coated fiberglas material, originally developed for use in space suits. Both of the above are examples of technology originally developed by the National Aeronautics

and Space administration (NASA) and later transferred to commercial use. NASA's technology transfer program has a rich history of success in this second area of technology transfer, often referred to as "spin-off".

A distinction has been made between "passive" transfer and "active" transfer. As defined by the General Accounting Office, in a study completed in 1972, passive technology transfer is " collecting, screening, indexing, sorting, and disseminating scientific and technical information upon request of a potential user". Active transfer is defined as "certain elements of passive methods supplemented by personal liaison between technology developers and potential users." The principle difference between the definitions is the interaction between the developer and the user. If the developer only provides information and documentation, the transfer is passive. If there is interaction between the developer and the user to enhance the process of transformation, then it is active [Ref. 4:p. 58]. The distinction between active and passive transfer was well illustrated by Milon F. Essoglou who stated:

> . . . we continue to act on the misconception that technology consist of reports...We seem to forget that technology transfer occurs when people do work. Transfer does not occur when reports are distributed or received . . . While it may be essential to make distribution counts of paper and reports, these counts are only a measure of effectiveness of our shipping system. The movement of individual knowledge cannot be ascertained unless reflected in use . . . . [Ref. 5: p.78]

The effective manager cannot rely on the slow and random process of passive transfer of knowledge or ideas. The constant infusion of putting technology into new uses must be made to happen through knowledge and manipulation of the active transfer process. To understand factors that influence the movement of technology or information from the source to a user it is necessary to understand the institutional forces and human interactions involved in the process. Once an understanding is developed it is reasonable to expect that a manager will be able to influence the movement of technology from a source to a user within a given organization. The following sections of this paper will discuss these forces and interactions in some detail.

III. THE PREDICTIVE MODEL OF TECHNOLOGY TRANSFER

The basic problem of technology transfer, when broken down to its simplest form , is quite simple. Information merely needs to flow from a source, who may or may not have been the originator, to a user, who has need or a practical application for the "new" information. (see Figure 1 [Ref. 11:p. 2])

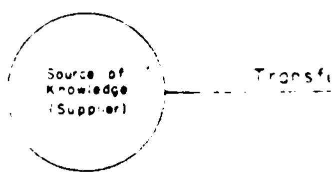

Figure I. A Simplified View of the Transfer Mechanism

The flow is normally viewed as occurring between two separate organizations, one being the source or developer and the other being the user or the implementor of the technology. In this context the source organization would be the research and development unit or laboratory of a corporation or other business entity. The user in this scenario would equate to the product development or marketing division of the business organization. In actual

practice the flow can occur at or between any of the divisions of an organization or between totally separate organizations. Although the above example is in terms of the private sector the same relationship also applies to Public organizations like the U. S. Navy. Regardless of the level or the scope of the technology to be transferred, the mechanism is basically the same and the success or failure of the transfer is highly dependent on the people involved [Ref. 6:p. 11] Although much research has been conducted on the transfer mechanism most of these studies have concentrated on the source side of the process. "One of the major drawbacks of past and present transfer activities is that the problem has been approached from the developer's side of the fence . . . ." [Ref. 7:p. 3] In Gilmore [Ref. 8:p. 37], one of the conclusions reached was, "Past attention to technology transfer has focused on the supply, future attention should focus on the demand side and on differences among user groups." Recently, during a technology transfer symposium [Ref. 9:pp. 2-4], M.E. Essoglou, senior technologist for the Naval Facilities Command, stated:

> "We R&D producers have been "operating radio stations" but we have no control over the "receiving radio sets" let alone the behavior and actions of our "listeners". Who has control over the "listeners" in an organization? It is the top management - that old cliche once again! Only top management can formulate policy and authorize resources for adequate "reception sets" and for "listening". They can economize total organizational resources by seeing that R&D "transmission" and user

"receptions" are matched as much as possible. We have been working from the transmission end mainly. It is the user, however, who can make the crucial and critical decisions towards implementation at the production level. I suggest that the future burden for technology transfer be shared more equally between users as well as R&D producers."

The lack of emphasis on the part that the user plays in the transfer mechanism is directly related to the notion of active transfer discussed earlier, where the point was made that there must be interaction between the provider and the user to have a successful transfer of technology.

To understand the transfer process further it is necessary to introduce a model. The model will serve as a tool, which is necessary to simplify the complexity of the transfer process into the relative variables impacting on a technology transfer effort. Although numerous technology transfer models have been presented in the literature this paper will deal exclusively with the Creighton,Jolly predictive model of technology transfer first published in 1972 [Ref. 10:pp. 2-9]. The reason for the selection of this particular model relates to the preceding comments regarding the reduced emphasis on the user side of the transfer process and has been well summarized by Jolly:

> . . . these other models tend to take a detached system approach to the problem rather than concentrating on the issues and factors from the potential users side of the transfer process. [Ref. 11:p. 2]

During its development Creighton and Jolly examined many existing models which were, for the most part, successful in

the achievement of a particular transfer. Examination revealed that the majority of these models had been described after the successful transfer had been accomplished, and generally described step - by - step activities rather than providing concepts. Often steps were repeated in one model many times which lead the authors to examine each step within many models to see if it performed some fundamental function in the transfer of information. This research resulted in a list of basic elements which seemed to include all the functional activities, and has become known as the predictive model of technology transfer. Its real character is that of a list of elements which contribute to the movement of information. [Ref. 12:p. 17] It is important to note that only four or five elements of this model are primarily impacted by the suppliers of technology. The other elements are the responsibility of the users.

The Creighton, Jolly model breaks down the transfer process into the various factors affecting the transfer mechanism, subdividing them into formal and informal factors. (See Figure 2) The "formal factors" are easier to conceptualize and are objectively measurable. They deal with mechanics and procedures used to index, store, retrieve and disseminate information. The "informal factors" deal with interpersonal communications, personal feelings about a knowledge source, and perceptions about one's organization,

supervisors and peers. The complete model is shown in Figure 3. The way these factors, both formal and informal, impact on management in a receiver or user organization determines whether they will enhance or inhibit the information flow process. To clarify these factors a complete discussion of each follows.

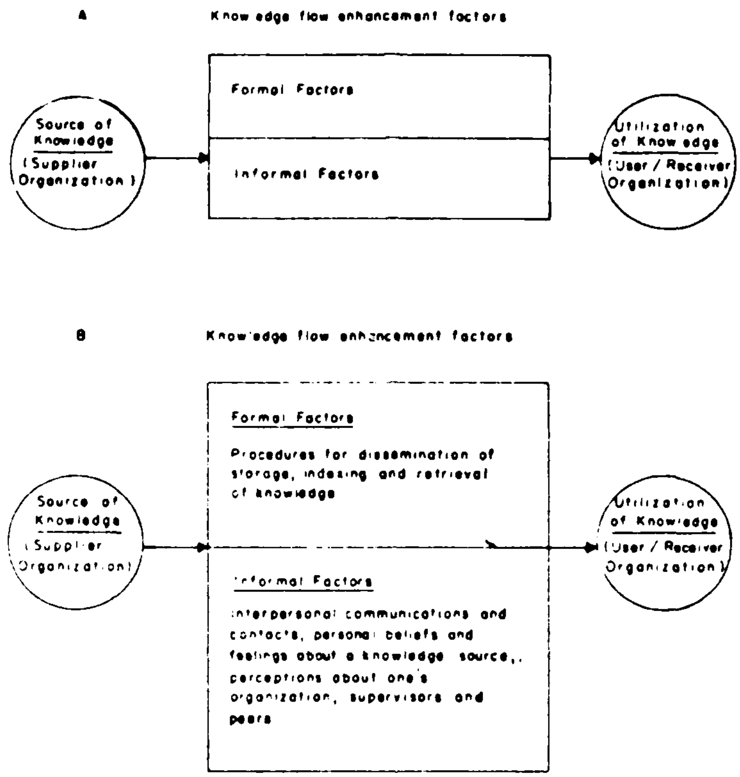

Figure 2. A Simplifed Model of Technology Transfer

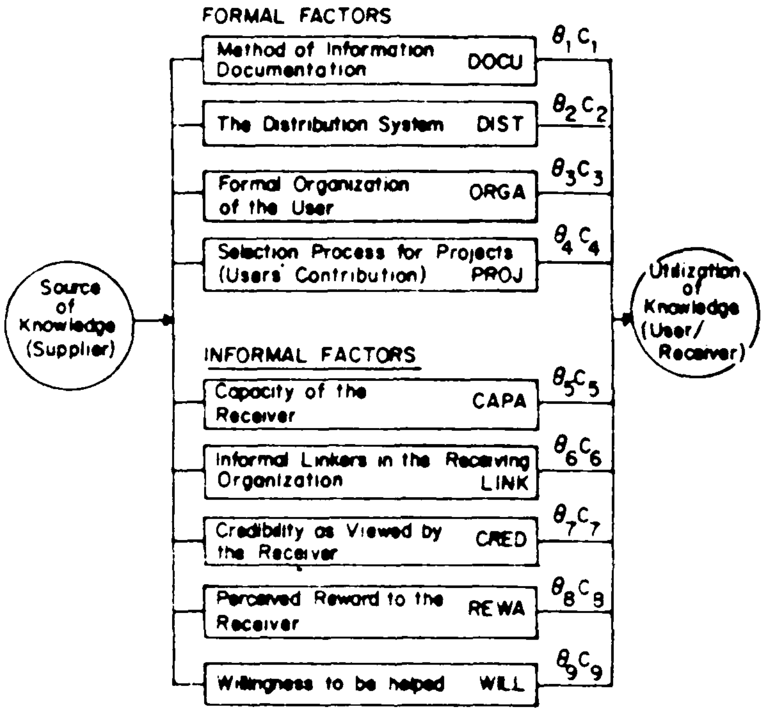

Figure 3. The Predictive Model of Technology Transfer

IV. FORMAL FACTORS

A. DOCUMENTATION

Documentation refers to the format, organization, presentation, and language of the material intended for transfer [Ref. 13:p. 24]. Language and format relate directly to the ease of use of the information intended for transfer. Information, no matter how potentially useful, is very unlikely to be utilized if it is not understood by the potential user. Often this user is not a research scientist but a line manager in a non-research organization, and research reports should be designed to meet line needs or understanding. However, as Howerton [Ref. 14:p. 27] has pointed out:

> . . . all disciplines are guilty of using their own argot and seem to be unable to understand why others cannot fathom the 'obvious' values of their discoveries. Technology cannot be transferred if it cannot be communicated in understandable form.

Often an area of research will be very well documented, yet not be well documented for transfer [Ref. 15:p. 5]. The issue of documentation as it relates to technology transfer is that documentation be performed in such a manor that the flow of information to another person or organization is enhanced and not inhibited. In organizations which use documentation to record the results of their effort, the

purpose of the documentation is often primarily for record-keeping purpose. Scientists working at R&D organizations and the line managers who run them are greatly concerned with insuring that research efforts are recorded and can be recalled for future use. Consequently the research is usually documented in a form which is clear to the scientist or technician who prepares it and his professional peers. Administrators are typically not held responsible with making the information known to specific and potential users. If the research was done well and if the documentation is understandable to the researchers peers then the work will be considered good and the researcher will be rewarded through additional funding of projects and the respect of his colleagues. The line managers will receive their recognition through the completion of another project. This reward system has evolved over time as the natural way for research and research organizations to receive recognition.

It is difficult to find fault with the performance or documentation that this system has produced. It may not enhance the flow of information to users, but it wasn't designed to. The system provides documentation oriented toward providing information understandable and useable by one's professional peers. In this situation the flow of information takes place when another professional peer, a scientist or researcher, uses the documentation for further

research. In this scenario, the researcher's environment encourages him to direct his effort toward producing results which gain status and professional approval. The production of research documentation which is understood and perceived to be beneficial by the general public is not the job of the researcher, it's not what he gets hired to do. Documentation which accelerates the flow of information transfer to people outside of a particular professional group is typically not part of the mission of R&D organizations. [Ref. 16:pp. 12-14]

Documentation for the purpose of technology transfer should be understandable by users other than the research scientist. If possible the form of documentation should be identified at the beginning of each research project with potential users or applications in mind. As Essogleu [Ref. 5:p. 78] points out:

> Todays information channels are so many and complex that we must have the user's cooperation to learn which channel was the effective one. This is important to us in the technology production business because it is we who must account to corporate or congressional management for the application effectiveness of our RDT&E expenditures.

Some organizations seriously interested in enhancing the ability of their documentation to promote information flow have adopted techniques designed to present documents to a range of potential users. For example, the Navy's Civil Engineering Laboratory has a procedure where several levels of users are considered and documentation is designed

accordingly. Additionally, the laboratory attaches a series of "Tech Notes" to improve the utilization of research information. [Ref. 17:p. 81]

The key point to consider in documentation designed to encourage technology transfer is that information can be expressed in many ways, each understandable or useable to a different group of people. If research documentation is in a form understandable by the perceived potential users, the chance for eventual utilization of that information may be greatly enhanced. [Ref. 16:p. 15]

B. DISTRIBUTION

Distribution in this context is the physical channel through which technology flows. It involves the number of inputs and ease of access into a particular channel, as well as the formal distribution plan, as they enhance or inhibit the flow of information to a potential user. [Ref. 11:p. 5] This definition implies that technology must enter the system and also be received. Reception cannot be assumed, and no distribution takes place unless someone receives the intended information. Distribution typically connotes many copies of written reports or other documents which are routed to potential users inside and possibly outside of the originating organization. However, this is not distribution within the framework of technology transfer unless the information contained within the reports are read,

understood and acted upon. In other words, there is no distribution unless there is a flow of information. As any manager knows the ever increasing volume of written reports in conjunction with the increasing time demands on personnel in the work place often make the distribution of information, as described above, ineffective.

In addition to an organization's formal distribution system there are many other types. Common ones, for instance,take such forms as newspapers, magazines, brochures, etc. In addition to printed documents there are vehicles such as video tape, movie, or verbal, as when people engage in conversation or when information is conveyed during a conference [Ref. 18:p 10]. Distribution should be considered as visual when any knowledge about something is witnessed. Computer databases are becoming a major source of information distribution [Ref. 19:p. 15]. Even the movement of people through job reassignment, temporary labor or inter organizational transfer represent a form of information distribution [Ref. 20:p. 15]. In addition to having many possible forms, a distribution system may purposely convey information or it may not. If information or knowledge is received about something, it has been distributed weather or not it was intentionally distributed. If the manager can match the form of distribution with the intended purpose and audience he can

have a great deal to do with the degree of reception. [Ref. 16:pp. 15-16]

C. ORGANIZATION

The element of organization deals with the potential technology users formal organization as it relates to the impact of that organization on the transfer process. The term "formal organization" is meant to consider such things as rules, attitudes, and role structure of specific business or governmental entities. Schon [Ref. 21:p. 211] describes the attitude of many formal organization toward technology change as :

> The . . . theory of the stable state, as applied to organizations, is the energy of adaptive change. In fact, in most organizations the structure of power, the nature of business, the organization of work, are all in the process of continual change . . . but there is a taboo against the acceptance of this change. The representative of a new order, in the organization, feels obligated to present himself as, for all practical purposes, permanent, and to behave as through the changes he is introducing will be the last . . . .

Schon [Ref. 22:p. 63] further describes formal organizations as:

> . . . In a state of dynamic conservation. It strives for survival, stability, and continuity. It is active in its efforts to achieve its objectives and to maintain its society, structure, functions, values, language, and style of operation.

The point is that formal organizations may establish bureaucratic tendencies which actively inhibit information flow and innovativeness, while at the same time expecting their managers to innovate and change things, and change

them for the better. Once the determination is made that a particular organization tends to accept or reject change the manager is better equipped to ascertain the mechanism and resources which will be required to introduce new or innovative ideas. [Ref. 11:pp. 6-7]

Wells and Waterman [Ref. 23:p. 118] stress that for a company to overcome resistance to change it is critical that management provide an organizational environment which motivates members to be innovative. All aspects of an organization which influence productivity and innovation should be of concern to the manager as he evaluates the movement of new technologies into use. The manager must take interest in the degree to which information flow is facilitated or blocked at various points in his organization.

Research indicates that informal relationships and communication networks that are allowed to perpetuate by the formal organizational structure are the most common vehicle to overcoming resistance to change. For example Barth [Ref. 23:p. 306] identified a significant correlation between informal inter group environment and an organization problem solving capability. The effective manager must be concerned with these flow patterns: the individuals through which a piece of information must pass. He must be interested in the reward systems which cause individuals to pass ideas or block them. When the manager understands his organizations

attitude toward change, knows the formal and informal communication networks and the various reward systems for passing or blocking information flow he is equipped to enhance information flow within his organization as he deems necessary [Ref. 16:pp. 9-10].

D. PROJECT

This element refers to the selection process that a technology provider utilizes and the contribution that a potential user organization has on that process [Ref. 11:p. 7]. Naturally the impact of the potential user on the project selection can vary greatly. Studies indicate that increases in the collaboration between provider and user increases the potential utility of research and strengthens the commitment on both parties much earlier in the technology transfer process. Kogan [Ref. 25:p. 573] has stated:

> . . . it is commonly accepted that research has a better chance of being used if researchers, practitioners, and administrators have participated at every stage of the planning, execution, and interpretation of the research.

With regard to the role that management should play in project selection and development Hertz [Ref. 26:p. 1] states:

> Innovation in industry is no longer just something nice to have; it has become a matter of survival. Studies show that a key factor in the firm's success with innovation is the involvement of top management. When management does not become involved in the direction its researchers take, it is abdicating its responsibility and could be placing the future of the firm in jeopardy. In

> fact, some findings show that up to one-half of the good research ideas developed in the chemical electronics and drug industries were originally suggested by top management.

For a practical example of collaboration between user and provider as well as the importance of management's involvement in project selection we can again return to the Naval Facilities Engineering Command. Essoglou [Ref. 5:pp. 85-56] has stated:

> Our effort to transfer technology from the laboratory to the operating world does not start upon completion of a research task. We have instituted a process that gives the ultimate user ownership of the project from the very start of research . We put our customer-users in the drivers seat by asking them to "approve" and "specify" at critical points of research activity, . . . Our management philosophy for RDT&E execution is based upon this user-producer dialogue.

The type of research activity which best lends itself to a collaborative effort between user and developer is applied research, which, almost by definition, is dependent upon user impact for validity. However, Garner [Ref. 27p. 570] argues that user influence is also necessary in basic research, stating:

> . . . it is just as valuable for scientist doing basic research to have communications with people who have problems that need solutions . . . for scientist to engage in goal oriented research, research aimed at solving problems already known to to exist is both to perform a service to society and to improve the quality of basic research itself.

Not every user organization is in a position to provide input to research facilities, particularly when a new technology is under development. Often technologies are

developed through basic research or spin-offs from applied research and then placed "on the shelf" until a potential user is identified. When a user does identify a certain technology that matches it's need, additional R&D will inevitably be required before marketing. Consequently, the importance of user developer collaboration appears significant regardless of the needed technology or it's stage of development. [Ref. 28:p. 35] A functional relationship between the R&D organization and the potential technology user is clearly an effective way for the manager to circumvent many of the barriers and accelerate the transfer effort. [Ref. 11:p. 8]

V. <u>INFORMAL FACTORS</u>

A. CAPACITY

This element of the model refers to the ability and capability of a potential user organization to utilize new and/or innovative ideas. The term "capacity" can be used to describe the collective abilities of individuals that are within an organization or can be used in reference to one individual [Ref. 11:p. 9].

Capacity, to a large extent, is a measure of wheather or not an organization or individual has the necessary resources to complete a given task. If a factory lacks the machines to insure production then it doesn't have the capacity. If an individual is given instructions in Spanish and he only understands English, then he does not have the capacity to carry out the instructions. More specificly capacity in terms of technology transfer is a measure of an organization's or individuals's ability to be innovative. [Ref. 16:p. 23] Research in this area has been primarily focused on isolating the personality traits and behavioral characteristics of those individuals with the capacity to be innovators, or early adopters of new practices and ideas. These innovator's contribution to the transfer effort is of paramount importance to the receiving organization. They will be the first in an organization, by definition, to give

a new technology a try. As stated by Rodgers [Ref.29:p. 92] innovativeness is ". . . the degree to which an individual is relatively earlier to adopt new ideas than the other members of his social system." By isolating the traits and characteristics of innovators one should be able to predict whether a particular individual has, and to what extent, innovative capacity. With this knowledge the manager is more able to accurately predict who in the organization has the ability to adopt a new technology, and therefore who is the best target for a transfer effort.

Loy, [Ref. 30:p. 349] during a study of 164 Ohio farmers and a sample of 99 innovators established that innovativeness was negatively related to age and positively related to social status, years of education, size of business involved, business income, amount of business specialization, outside communication and opinion leadership. Additional predictive research also conducted by Loy [Ref. 31:p. 77] determined six attributes (venturesomenss, professional status, imaginativeness, educational status, dominance, sociability, and cosmopolitaness) that were significant in predicting innovativeness. Additionally, he identified nine attributes (perseverance, peer status, intelligence, occupational status, social status, shrewdness, experimentiveness, surgency, and sensitivity) which did not appear important in predicting innovative behavior.

The exact formula or proper mixture of characteristics that give an individual or organization the capacity to be innovative remains undefined, but the concept is established well enough to be of assistance to managers. One of the functions of a manager's job is to build the capacity he needs or desires to complete the tasks he has been charged with. Ways of building the desired capacity include the obvious, such as training, and also such things as changing the working environment. These changes could include better equipment, safer conditions, increased division of labor, more independence, rearranging of personnel and jobs, hiring of temporary help and many others. All these possibilities are the kinds of things that managers do every day, but typically are not thought of in the context of technology transfer. The manager who introduces a new approach, technique or process has done so by increasing the capacity of his organization.

Capacity should not be interpreted as only an issue of identifying innovative behavior, but as a matter of giving due recognition to the significance of the capacity of all players and groups in the organization which is trying to adopt a new technology. [Ref. 16:pp. 23-24]

B. LINKER

The linker is an individual, and the term refers to presence of these people and their effect in coupling their

organization to the larger environment [Ref. 11p. 9]. The term may also imply a third party individual acting as a intermediary between a source of information and the practical application of that information. The linker functions to bring one individual or group in touch with the relevant part of the environment though whatever media is appropriate [Ref. 31:p. 77].

Numerous other terms have evolved in the literature about technology transfer which have a similar connotation. Among them are: technological gatekeeper, change agent, liaison agent, innovator, technological innovator, innovation coordinator, opinion leader, and transfer agent. The meaning for all of these terms are similar to the one given for the linker. They all imply an assistance or catalysis role in the transfer of knowledge. The difference relates to what type of organization is being discussed (information provider or information user) and that the adoption of a innovation by one party does not necessary mean that the innovation will be adopted by another. [Ref. 12:p. 53] The point is that the important role of the linker has been recognized by one term or another by everyone who works with technology transfer [Ref. 16:p. 22].

The primary way linkers obtain their information is through "informal, interpersonal channels of communication," [Ref. 32:p.2]. This is supported by the findings of Katz [Ref. 31:p. 77] who concluded, ". . . despite their greater

exposure to the media, most opinion leaders are primarily affected not by the communication media but by still other people." Linkers tend to be part of information networks, both formal and informal, often as the opinion leader. They tend to be receptive of ideas and perceptive to possible uses for them. Their character invites comment and offers of information. They can be of value to the manager not only as an idea or information mover, but also as an evaluator of potential uses and applications. They assist in the overall communication process. The effective linker can also be an effective communicator of rumors or any other kind of information. People with the ability of linkers to communicate up or down in the organizational hierarchy can often give effective counsel on the interpretation that people throughout an organization will place on directives and announcement made by management. [Ref. 16:pp. 21-22]

Linkers tend to be providers of information and are not necessarily action oriented except in effecting transactions of the "right" information between the "right" people or organizations. The role in the transfer process should be contrasted with that of the advocate, who's role is single purpose with a sharp focus. The advocate needs to direct or influence the commitment of resources and managerial decisions. The linker is seldom interested in the allocation of resources, and is content to leave this to those individuals with that managerial responsibility.

Linkers operate best when there are few restrictions, and can usually find a way of working around restrictions that do appear. On the other hand, the advocate is likely to depend on a rigid working environment with close supervision. The generation of information and the utilization of it are rarely participated in by linkers. [Ref. 16:p. 19]

It is not always possible to identify a particular indivigual as a linker or to determine that a linkage has occurred or how it occurred. Managers should be satisfied that linkages will happen without their intervention, but can be aided by their support. [Ref. 16:p. 17]

C. CREDIBILITY

This element of the model refers to an individual's perception or assessment of the reliability of the information he must deal with. It is evaluated by analysis of both the source and the channel of receipt. Typically individuals have some difficulty distinguishing between the origin of information and the channel which carries that information, consequently a composite credibility assessment based on both factors is assigned to information. [Ref. 11:p. 10]

Gallup [Ref. 33:p. 235] stated, "the character of the group most closely concerned or identified with the idea will be an important factor in determining how fast it gets

into the blood stream." This conclusion is supported by Aronson et al [Ref. 34:p. 3] who demonstrated that opinion change has a definite relationship with the credibility of the source. Among their findings they stated that "It is apparent that the highly credible communicator was more successful in inducing opinion change than the mildly credible communicator at every point of discrepancy (from the receiver's initial opinion)."

Credibility as a factor in the technology transfer process is usually meant to be the credibility of a technology provider as perceived by the potential user. Others [Ref. 16:p. 25] have expanded meaning of the term to include the perception of any person of another individuals knowledge, power, capacity, or influence, and expanded the context to include the credibility interactions within an organization as well as external to it. Viewed in this larger context the role of the manager is also expanded:

> A manager's use of an understanding of credibility in the communication or transfer of technology based systems may depend a great deal upon his knowledge of the credibility of individuals toward each other within his organization. To put a work team together, when the members of the team have no respect and lack confidence in the capability of other members of the work team, is almost certain to produce an environment from which constructive work by the group will be difficult to obtain. [Ref. 16:p. 25]

Managers can and should take an active role in building the credibility of the various parties involved in a project. For many people the credibility of other individuals or organizations must be evidenced or proved before the

provided information will be excepted. The proof required will vary greatly from person to person, but cannot be assumed. It is important for managers to take the time at the beginning of a new initiative or project to establish any unknown credentials for the purpose of breaking down the credibility gap. [Ref. 16:p 26]

The typical manager will be confronted with information from many sources and through many channels both from within and from outside his organization. How he reacts to that information and whether or not his organization can successfully assimilate it depends on his perception of the source's credibility and how well he influences his organization's perception of the source credibility. [Ref. 11:p. 11]

D. REWARD

This element refers to the perceived and actual recognition of innovative behavior in the social system of which the individual is a member [Ref.17:p. 84]. As Lingwood and Morris [Ref. 35:p. 121] stated:

> Obviously, rewards are the glue which holds organizations together and provides the response to individual needs for recognition of accomplishment . . . no researcher is going to get very involved in application work if he does not see a predefined and operating system of rewards for such work.

Research [Ref. 36:p. 139] indicates that reward can be broken down into two types. The obvious "extrinsic" rewards such as salary or administrative authority and the more

obscure "intrinsic" rewards like opportunity: to use skills, to gain new knowledge, to deal with challenging problems and to have freedom to follow up on one's own ideas. Another study [Ref. 37:p. 114] has indicated intrinsic rather than extrinsic reward is much more effective as a motivator for most people. Extrinsic rewards, like money, may even have a negative impact on certain desired behavior by working to ". . . buy off one's intrinsic motivation for an activity."

Rewards, particularly the intrinsic kind, are preceived differently by different people, even when similar tasks in the same organization are involved. One individual may thrive on constant attention, and another may view the same attention as mistrust. Managers must gain a through understanding of the reward system as it is perceived by the individuals in their organization before they can fully utilize the power of reward as a motivator. Rewards for motivation should be treated like any other behavior a manager desires to encourage, but with special caution. There is a high degree of risk surrounding anything new. In this high risk environment reward systems can easily encourage the wrong behavior. If a person innovates and fails (many more innovations fail than succeed) the reward may very well be loss of status, position or even a job. In this situation, which is not uncommon, the behavior that is motivated is not to innovate, but to play it safe and maintain the status quo. When there is innovation it is the

manager's job to ensure that there is adequate evaluation and proper reward. This action will ensure that an innovation is sustained in operation if merited and provides the necessary foundation for reward of technology transfer. [Ref. 16:pp. 29-32]

The concepts and obscurities of a reward system were well summarized by Pelz and Andrews [Ref. 36:p. 139] who stated:

> The implication is that the research director (or manager) must give close attention to the whole system of rewards - both intrinsic and extrinsic. He must hire with the paradox that extrinsic rewards cannot be relied upon to motivate achievement, but that when achievement occurs, the extrinsic rewards should be consistent.

E. WILLINGNESS

This element relates to the individual's ability and desire to accept innovation or change in the organization where he works [Ref. 11:p. 11]. Change in this context means anything new or different: new procedure, different policy, updated process, etcetera.

Resistance to change occurs because of a "normal human instinct to protect one's way of life." [Ref.22:p. 82] It represents a major barrier to technological change and innovation, and is closely related to the reward element discussed in the preceding section. A manager's primary tool for dealing with resistance to change among personnel is through the organization's reward system. A manager who is skilled in the use of reward systems can apply that

expertise to the encouragement of innovation or other desired behavior.

Even through an idea or innovation may have been excepted "in principle" there is still a reluctance to evaluate and incorporate it into daily operations. Berlin [Ref. 38:p. 112] noted that ". . . resistance to change sometimes takes the form of acknowledging the relevancy of new ideas and methods but not excepting them in practice or trying them out fully in new training and practice areas." The resistance to implement innovations which are generally excepted relates to the amount of risk involved. As indicated in the last section, when risk is involved an individual often will not try an innovation. The trial would consume time and other valuable resources and then could fail. If the individual is evaluated under a reward system which penalizes him for wasted resources, only "sure things" will be implemented, and an environment that fosters resistance to change will be encouraged. As stated by Jolly [Ref. 11:p. 12]:

> Awareness then, even first hand knowledge of a new and/or innovated idea, is not sufficient to assure its use. There must be a willingness and interest or perhaps more significantly an internal motivation to utilize a better method, process, or concept.

VI. CONCLUSION

Now that all the factors effecting the flow of information have been examined it is clear that managing the elements of technology transfer is no simple task. Specific factors, pa· ·icularly the informal factors, cannot be isolated because they are so interrelated, each one influencing the quality of all the others. The manager cannot set the goal that his attention should be directed toward all the elements. There simply isn't time to indulge in this kind of effort. The importance of the factors is to gain an overall understanding of the forces involved so that the manager can work in the direction of establishing an organizational environment in which innovation can occur.

Research indicates [Ref. 16:p. 33] that the movement of technology is inhibited by deficiencies which exist in several elements at the same time, and not in a single element. Another study [Ref. 39:p. 81] has indicated that no individual element is singularly more important than any other, but that certain elements are more important than others in particular situations. Each organization and each situation has its own mix of the various element attention needs, and you cannot affect one without influencing the others. Generally if the mix has more innovation enhancers than inhibitors the organization will tend to be a higher

performer in terms of acceptance of change, profitability and productivity. This may be true even if it displays inhibitive characteristics in one or two of the elements. As the inhibitive traits of the elements continue to rise a threshold is reached where the organization will not accept innovation.

It is left to the individual manager to assess his own organization, determine where it lies on the innovative continuum, and what actions he can take to start his organization in the innovative direction.

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